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THE EFFICIENT USE OF FUELS IN THE UNITED KINGDOM

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THE EFFICIENT USE OF FUELS IN THE UNITED KINGDOM

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1. In the last decade there has been, in general, a decline in the consumption of raw coal and an increase in the consumption of electricity and oil in all the main sectors considered in this paper. The use of electricity for road transport has, however, declined and the use of coke in domestic premises increased.(1) The changes in consumption of fuel and power have been accompanied by an all-round improvement in the efficiency with which they are used.

General Measures to Promote the Efficient Use of Fuel

2. During the inter war period 1919-1938 there was no very great incentive for the development of fuel efficiency measures in the United Kingdom because coal was both cheap and plentiful.

3. A body of professional engineers known as the Institution of Fuel Economy Engineers was already in existence in the early part of this period. This body merged in 1927 with the Institution of Fuel Technology to form the Institute of Fuel which has continued to have fuel efficiency as one of its main objectives.

4. From 1939 onwards, the Government actively encouraged interest in the subject. In 1941 a Fuel Efficiency Committee (F.E.C.), was set up to deal with all aspects of industrial and domestic fuel efficiency. Regional Committees were appointed and they received considerable

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(1) Ministry of Power, Statistical Digest, 1961, Table 8. Her Majesty's Stationery Office, London.

voluntary assistance from industrialists, engineers, scientists and others, and excellent collaboration from such organisations as the Federation of British Industries, Trade Associations, the Trades Union Congress and Regional Boards for Industry.

Industrial

5. An important step taken by the F.E.C. was to initiate the construction of heat balances at factories, by means of which the energy actually used could be compared with the theoretical energy required. This was followed by the introduction of mobile testing units which provided valuable quantitative advice to any firms on payment of a nominal fee. Experience showed that in average cases fuel savings of some 20 per cent could be obtained by implementing the recommendations made following surveys made by these testing units.

6. The importance of education and publicity in fuel efficiency matters was not overlooked. Two text books "The Efficient Use of Fuel" and "The Efficient Use of Steam"(2) were compiled under the auspices of the F.E.C. and published, together with over 50 Fuel Efficiency Bulletins and a number of instruction manuals. Educational courses were also developed and examinations in Boiler House Practice, Combustion Engineering, Instrument Maintenance, Heating and Ventilating and Fuel Technology were started.

7. National Industrial Fuel Efficiency Service. In 1953, it was decided to set up an independent non-profit making organisation to take over and expand industrial aspects of the work previously undertaken by the Government. Financed initially by the nationalised coal, gas and electricity industries, the National Industrial Fuel Efficiency Service was formed under the auspices of the British Productivity Council. This patronage was considered appropriate because the Council is representative of industry as a whole, it is independent of Government control, and fuel efficiency can make an important contribution to National Productivity. The sponsorship of N.I.F.E.S. has since been extended to include some of the oil companies.

8. The N.I.F.E.S. commenced operation in May 1954. The professional and technical engineering staff now numbers 184. Since its formation nearly 11,600 contracts have been undertaken and over 169,000 engineer-days service provided to clients. Over this period it is estimated that the total fuel savings due to N.I.F.E.S. activities amount to more than 13 million tons of fuel. The organisation has also trained over 6,000 boiler operators, and has produced a New Stokers' Manuel of which over 26,000 copies have been sold. In the last financial year the earnings of the organisation from chargeable services amounted to 88 per cent of their costs.(3)

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(2) Her Majesty's Stationery Office, London

(3) National Industrial Fuel Efficiency Service, Progress Report No.8 p.5., (1962).

9. Other Advisory Services. In addition to the foregoing, technical advisory services to fuel consumers are also provided free of cost by the coal, gas and electricity industries, the major oil companies and fuel distributors.

Domestic

10. From 1940 to 1951 domestic fuel efficiency was also mainly the concern of the then Ministry of Fuel and Power (now Ministry of Power). In 1951 some aspects of the solid fuel work were transferred to the Coal Utilization Council, which is a body representative of coal producers and distributors, and appliance manufacturers and distributors. The objective of the Council is to promote the efficient use of solid fuel in the home (a) by encouraging the coal and appliance trades to give a high standard of information, advice and service to the consumers, (b) by providing training facilities to enable the staffs of these trades to sell and service their goods to the best advantage and (c) by advertising the services available to the public, publicising the advantages of solid fuel and assisting the coal and appliance trades in providing their own publicity.

Legislative or Financial Measures to Assist Fuel Efficiency

11. Government Loan Scheme. In 1952 a Government Loan Scheme was instituted to promote efficiency amon small and medium sized industrial establishments. Money was loaned to finance most types of fuel efficiency measures in existing factories on condition that these resulted in substantial fuel saving and were such that in the absence of the Scheme they would not have been undertaken. Between 1952 and 1959 when the Scheme was terminated, the Government had lent about £5 million to assist about 1,100 schemes in the expectation of saving 360,000 tons of coal or its equivalent per annum.

12. Tax Allowances. From 1956 to 1959 a special taxation concession, known as the Investment Allowance, was retained as an additional incentive in respect of capital expenditure incurred on industrial fuel saving measures.

13. Clean Air Act. As the culmination of much public discussion on the evils of atmospheric pollution the Clean Air Act was passed in Parliament in 1956. Its effect on industrial fuel efficiency is likely to be beneficial since it requires plant to operate smokelessly. The Act is also affecting the pattern of fuel usage in domestic premises.

14. Insulation. In 1957 Parliament adopted legislation requiring a minimum standard of insulation for all new factory buildings erected after 1st January 1959.

Efficient Use of Fuels in Industrial Installations

15. Investigations carried out in the highly industrialised United Kingdom in the early post-war years provided conclusive evidence that

fuel consumption in existing factories could be reduced on average by some 20 per cent. Even now after many years of fuel efficiency crusading, savings of the same order are frequently found to be potentially realisable. This position is not likely to be any better in countries less highly industrialised.

16. Experience has clearly demonstrated two facts. Firstly, that the average level of plant operation is far lower than it should be and secondly, that installation of new plant will not necessarily improve efficiency unless the operator is properly trained in its use, and the plant is well maintained.

17. Whilst a qualitative assessment of the performance of existing industrial plant can often be made by visual observation, an engineer, no matter how experienced, cannot properly assess a boiler efficiency, discuss a furnace performance, or improve the performance of any heat using plant without measurement. One of the first steps towards improving fuel efficiency is therefore instrumentation to an acceptable standard. This has to be followed by the better training of operatives and better supervision of operation and maintenance by those responsible for boilers, industrial furnaces and process plant.

18. If the fuel costs of the factory are to be reduced to a minimum, steam, air, gas and water flow meters, temperature recorders etc., need to be installed to obtain continuous records of process requirements. It is found that a far more rigid control of operation and a higher degree of efficiency result from the increased use of instruments. Temperature, humidity, flow, etc., can all be controlled far more accurately with the aid of instruments than by rule-of-thumb methods, and once an operative has been taught the operation and function of instruments and controllers, he gains confidence in them and is able to devote more time to proper supervision of the plant.

The Technique for Improving Efficiency

19. With adequate instrumentation every factory can measure the quantities of fuel heat and power which it uses to manufacture a given number of units of standard quality product with the minimum of reprocessing or rejects. An endeavour should be made to break down the overall quantities into the individual process unit requirements. Such figures having been obtained, a heat balance can be prepared for the existing factory conditions. This will show the specific fuel and power consumption per unit of product for the factory as a whole, and the specific consumption of unit processes. If only the chief users of heat are considered, the most fruitful sources of savings (all the subsidiary heating requirements) may well be overlooked, even though they may take more heat in the aggregate.

20. The next step in determining the scope for improvement in fuel and power utilisation is to calculate as accurately as possible the theoretical heat and power requirement of each process and a "theoretical" heat balance can then be drawn up and compared stage by stage with the existing heat balance. This comparison will give an indication of the scope for

the better utilisation of heat and power and lead on to setting up a "target" for the process as a whole.

21. The establishment of a "target" must be a two-stage operation. In the first stage it is essential that each unit of plant should be made as efficient as possible. The second stage is to find the best inter-relationship of the individual units, so that the heat rejected by one may be used as the source of heat for another.

22. In the first stage, two fundamental questions must be answered: (i) can the escape of heat be prevented? and (ii) can the work to be done be reduced?

23. Consideration of these questions, and the subsequent carrying out of improvements, will give those responsible a true picture of what is going on in the factory and will make the operatives "fuel conscious".

24. The second stage of the operation focuses attention on the amount and grade of heat required by each process and rejected by each process. If the heat required or rejected cannot be metered it must be calculated from knowledge of the plant and the process being carried out. Wherever low grade heat is available, it is necessary to ascertain that full use can be made of it before attempting recovery. It may be necessary in order to recover such heat to instal waste heat boilers, air heaters, economisers or heat exchangers, water treatment plant and water storage tanks. Industrial furnaces may require recuperators, regenerators or some other form of heat exchanger and it may be necessary to prepare schemes for the utilisation of the heat recovered in some process plant remote from the furnace itself. Allowance must be made for any properties of the medium carrying the rejected heat (e.g. tendency to cause corrosion, abrasion or fouling) which may make heat recovery plant costly or uneconomical. These factors having been considered, it is possible to obtain a target for the minimum amount of fuel, heat or power which it is economic to employ for a unit of product and against which operating practice can be measured.

25. It will be clear that in many complex cases this type of work can only be carried out by a qualified specialist with a long experience behind him of the problems involved. Experience shows that 70 percent of the recommendations made arising from such surveys can be carried out with little capital expenditure.

Combined Heat and Power Generation

26. Industries fall into three categories: (i) large steam users whose steam demand is always so great that it is potentially possible to generate simultaneously more than sufficient power for their needs, (ii) those whose power and steam requirements are normally balanced and (iii) those whose power requirements are greater than could be met by back-pressure generating plant.

27. Factories in the first and second categories tend to become upgraded to the second and third. In general the more efficient a factory becomes

the sooner does it pass into the third category, because every economy in steam used or heat conserved in the factory processes reduces the amount of steam available for power generation. Most technical improvements, particularly of a labour saving character, reduce the factory heat demand and increase the power demand.

28. A large factory in category (i) or (ii) can generate power with a consumption of only 40 per cent of the coal used by a modern condensing power plant, by first passing the steam on its way to the heating process through an engine or turbine. Even a modest engine in a small factory need only use about 66 per cent of the coal burnt per unit generated by a condensing power plant.

29. Factories in category (iii) can either purchase their excess power from the public supply or generate their own by condensing part of their steam. There are many old-established factories in this category, generating their own power as a matter of custom but unless these factories are using the exhaust steam from their engines or turbines, at least in part for process work, they may be using, to take extreme cases, two or three times as much coal as the large condensing power plant of the public supply.

30. The official statistics for the U.K.[4] show that, discounting power produced by nuclear means, the total power generated by industry is now almost exactly what it was 10 years ago, about 11,000 million kWh, although a peak figure of 12,400 million kWh was reached in 1955.

31. The only detailed survey of "Steam and Power Usage"[5] in the U.K. was carried out in 1952-3 and suggested that there was scope, by installation of back-pressure generating sets, for saving some million tons of coal per annum.

32. Whilst the potential savings may appear attractive, thought has to be given to the varying conditions of specific industries and individual concerns, the cost of the necessary equipment, the prices of available fuels, and the necessity to discuss tariffs for the alternative supply of power from the national grid. When all these factors and others are taken into account, the advantages of combined heat and power generation are often marginal in many industries.

The Efficient Use of Fuels in Domestic Consumption

33. Nearly 30 per cent of the total consumption of all fuels is used in one form or another for domestic purposes. The chief changes which have occurred in the consumption of individual fuels in the domestic sector in

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(4) Ministry of Power, London, Statistical Digest 1961, Table 66

(5) Ministry of Power, London, Statistical Digest 1953, Tables 5-26
Her Majesty's Stationery Office, London

the last decade are a reduction in the consumption of raw coal from 58 per cent of the total to 46 per cent, an increase in the consumption of electricity from 18 per cent to 32 per cent, and an increase in the use of all fuels of 11 per cent. In the same period, the number of dwellings has increased approximately from 14.2 million to 16.7 million, or by 17½ per cent.

34. Liquid fuel plays only a small, but growing, part in domestic heating. A certain amount of oil is used for central heating and paraffin for individual room heaters which are also frequently used to provide supplementary and occasional heating in halls, passages, bathrooms etc.

35. Most dwellings in the United Kingdom are heated by individual room heaters. There is, however, a trend towards central heating, which is influenced by a number of factors such as the growing desire by many people for improved standards of heating, the increasing numbers of tall blocks of flats and the development of heating appliances which will provide economically full, or background, heating services.(6) Grouped building and district heating arrangements by means of thermal or thermal electric methods are installed, and experience has shown these are more likely to be economic when the building density is high. In new developments there may be special opportunities to combine the generation of electricity with district heating schemes. Many new blocks of flats are warmed by electric under-floor methods in which the heating cables are embedded in the floor structure. Off-peak electricity can be used with this and other forms of electrical thermal storage heating and the electricity supply authorities encourage its use by means of special off-peak tariffs.

36. Much emphasis has been placed on increasing the efficiency with which fuel is used in the home. Experimental houses have been erected to study the efficiency and economy of various combinations of space heating, water heating and cooking appliances and of differing standards of insulation.(7) This work has been supplemented by field tests and by surveys in various parts of the country of expenditure on heating and on tenants' reactions to differing methods of heating in houses and flats.(8) (9)

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(6) "Special Study of Domestic Heating in the United Kingdom" - Various Authors. The Institute of Fuel, London, 1956.

(7) Weston J.G., "Heating Research in Occupied Houses", J.Instn.Heat, Vent.Engrs., 19, (189), 47 (1951)

(8) Gray P.G., "The Use of Heating Appliances and the Expenditure on Fuel by Urban Households Living in Dwellings of Medium and Low Rateable Value". Central Office of Information, London (May, 1954)
Gray P.G., "Domestic Heating", Central Office of Information, London (1958)
"A Study of Space and Water Heating in Local Authority Flats, 1956-1959". National Building Studies, Research Paper No. 34, Her Majesty's Stationery Office, London.

(9) See over.

(9) Methods have been devised of accurately measuring smoke emissions from the appliances. (10)

37. Standards for domestic solid fuel appliances are prescribed in British Standard Specifications (11). In general these appliances will burn either coal or solid smokeless fuels. In addition, automatic gravity feed boilers are available which operate with a range of graded solid smokeless fuels. The overall efficiencies of the appliances when burning smokeless fuels range from nearly 50 per cent for the open fire to about 75 per cent for the gravity feed boilers.

38. Appliances which meet the British Standard Specifications may be included in a list of approved domestic solid fuel appliances which is used by local authorities and others in selecting solid fuel appliances for new houses. Similarly, lists of tested and approved domestic gas appliances and of recommended domestic electrical appliances have also been compiled. Advisory services for local authorities, architects and householders on the domestic use of fuels and on the appliances in which to burn them are provided by the Coal Utilisation Council, the Solid Smokeless Fuels Federation and the fuel and power industries.

39. The standard of structural insulation in new dwellings is controlled by byelaws. In existing houses, an economic method of reducing heat losses at small cost is to improve the insulation of the ceiling of the upper rooms. Information on methods of insulating existing houses is made readily available to occupiers.

40. The Clean Air Act, 1956, is having an important effect on the domestic use of fuel. The Act, among other things, enables local authorities to promote smoke control areas in which smoke from chimneys of any kind is prohibited. By mid-1962, 567 smoke control orders covering 626,000 premises were in operation, and a further 498 orders covering 653,000 premises had been confirmed or submitted for confirmation. Most of the householders in smoke control areas who were previously using coal changed to solid smokeless fuel. At the same time there has been an increase in the numbers of electrical and gas appliances in smoke control areas.

Transport

41. The efficiency of the use of fuel and energy in transporting goods and passengers is a subject which has received much attention since the

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(9) Davison, M. Kimber, D.E. and Tulett R.E.J., "Field Tests to Evaluate the Performance of Free-Standing Convector Fires with Restricted Throats", J.Inst.Fuel, 28, (170), 123 (1955)

(10) Dickinson R, and Kimber D.E., "An Electro-Precipitator for the Assessment of Domestic Smoke" and "Some Measurements of the Smoke Emission from Domestic Appliances", National Society for Clean Air, International Clean Air Conference (1959) London, Papers 54 & 55

(11) British Standards 758 Parts 1 and 11: 779; 1252; 2845, Parts 1 & 11; 3128; 3376; 3378. British Standards Institution, London

last war. The comparisons made between the various prime movers are often based on those factors, particularly of costs, which can be fairly readily assessed and may ignore many others which are not so obvious, e.g. paid for out of a social service. Particularly is this the case in old established countries where to an appreciable extent the methods of transport in use are traditional. Newly developing countries may be in a better position to achieve systems of transport which are efficient from all aspects and most suited to their needs.

42. In the U.K. probably the most significant change in the whole field of transport, except in the air, is the way in which the diesel engine has tended to oust other forms of prime mover. This is because of the higher efficiency of the diesel in terms of energy yielded to fuel consumed and because in general a wide range of liquid fuels can be utilised by appropriate design of the diesel engine.

Road

43. Electrically operated tramways and trolley buses, once very popular in British cities, have now almost completely disappeared. Whilst efficient in energy consumption and utilising indigenous fuel and capable of moving large numbers of people quickly, they have given place to diesel engined buses on grounds of the high capital cost of installing the necessary electrical wire and cable systems and the inflexibility in routes which results from these systems and also because under the heavy traffic conditions found in many cities, they lacked mobility. Public passenger road transport[12] and heavy goods vehicles are now almost wholly diesel engined. Despite the use of higher compression ratios the petrol engine (efficiency 20-28 per cent at most) is not capable of competing with the road diesel (efficiency 30-42 per cent) in running costs and only maintains its hold in the private car field on grounds of quietness, smoothness and wider speed range. Light goods vehicles and taxis are becoming increasingly diesel engined because of their outstanding fuel economy.

Rail

44. The diesel engine and, when appropriate, electrification, are rapidly ousting steam on British railways. Here the efficiency of the diesel is not so high as in road work because of the losses in the electrical means usually adopted to transmit the drive to the wheels, which results in an efficiency of some 28 per cent. This compares with 7-8 per cent for the steam locomotive at best and which is considerably lower when used for shunting. As a result of this and other factors,

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(12) Wilford A.T., "Fuel Economics of Public Road Transport." J.Inst.Pet., 12, 227, (1958)

of which an important one is the extension of electrification, the coal consumed by the railways has fallen from 12.2 million tons in 1956, when the use of diesels commenced, to 7.7 million in 1961, whilst diesel oil consumption has risen only from about 19,000 tons to 430,000 tons, during which period there has been little change in train-miles. It remains to be seen how the life of diesel locomotives compares with those of steam. Electrification schemes which should show an overall efficiency of about 18 per cent, based on coal delivered to the power station, are being installed on those lines where traffic density warrants the high capital cost.[13] [14] These schemes are based on the use of power from the normal electricity supply at 50 cycles and 25 kV. Power for electrification does not yet represent a substantial proportion of the fuel and power bill of the railways.

Canal

45. Many of the canals of the U.K. were in existence before the railways but a number have now been abandoned. The diesel-engined barge is the normal unit to-day, but restricted width in locks prohibits, over much of the system, the use of barges greater than 7 feet beam and hence limits their carrying capacity to 20-25 tons. Diesel oil now represents the bulk of the fuel used in water transport.

Sea

46. At sea the diesel engine is likewise making considerable progress. Whilst for oil fired turbine ships the propelling machinery is considerably lighter than the diesel engine of corresponding power, the latter because of its high efficiency at sea, which may be 40 per cent, is, when considered together with its fuel, appreciably lighter. Whilst the diesel engine is now becoming available in much higher powers there are for marine work other considerations which may still favour steam. Gas turbine propulsion has made little headway. Designs are being considered in the U.K. for nuclear powered ships.

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(13) Wheatcroft E.L.B., and Barton H.H.C., "The Potentialities of Railway Electrification at the Standard Frequency". Inst.Elec. Eng. 103, 411, (1956)

(14) "British Railways Electrification Conference", Engineer, 210, 587 and 621, (1960)

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